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ABSTRACT

This paper compares students' reports of the mathematics courses they took in high school with their post-graduation transcripts, and examines the relationship between various measures of mathematics course-taking and average National Assessment of Educational Proficiency (NAEP) scores. There were 6,311 grade-12 students in the NAEP, and transcripts were obtained for 3,903 of them. Data indicate that exact match rates were low, at less than 50%, but that most of the nonmatches involved only 1 course. Students who did not match usually claimed to have a deeper mathematics background than did their transcripts, but a notable number of students reported a more shallow background. For most measures of mathematics study, there tended to be an increase in proficiency with each additional level of mathematics study. The monotonic pattern showed a positive relationship between average proficiency and the math study indicator. Students with incomplete sequences of mathematics courses tended to have lower average scores than students with complete sequences. For any given category, statistically significant differences in average proficiency scores showed higher scores in the transcript data than in the self-report data. This suggests that using self-report data may result in marginally attenuated proficiency scores. (Contains 1 table and 11 figures.) (SLD)

Mathematics Course-Taking and NAEP Math Proficiency: Comparing Students' Reports with Their Transcripts

Mary Naifeh and Sharif Shakrani

Introduction

In this paper we compare students' reports of the mathematics courses they took in high school with their post-graduation transcripts. We also will examine the relationship between various measures of mathematics course-taking and average NAEP proficiency scores. Basically, we want to answer three questions.

- Do 12th grade students accurately report their mathematics study in high school?
- Do students' reports tell the same story as their transcripts about their mathematics proficiency ?
- How do different measures of mathematics study tell this story?

To answer these questions, we use the reports of math course-taking by grade 12 students who took the NAEP math assessment and link these students with their transcript. We describe the prevalence of the match between these two sources and identify the nature of disjunctures. After developing independent measures of mathematics study from each data source, the pattern of each measures' relationship to NAEP proficiency scores is examined and the similarity or differences between the indicators from the two data sources are noted. In addition, a new measure, that attempts to describe the diverse patterns of mathematics study, is presented and evaluated.

Data Sources

In 1990, NCES conducted both a math NAEP (National Assessment of Educational Progress) assessment at grade 12 and, at the end of the year, obtained transcript data for students who graduated. These data provide the 3 basic pieces of information used in this study:

1. Students responses to taking 11 math courses
2. Transcript data showing which courses students' took, and
3. NAEP math proficiency scores.

There were 6311 Grade 12 students in the NAEP mathematics assessment. After the close of the academic year, transcripts were obtained for 3903 students. This represents 62% of the students. The primary reasons that transcripts are unavailable for the remaining 2408 students include:

- student NAEP identifiers were not retained by school,
- some students did not graduate, and
- transcripts were not available.

The major factor was the inability to match students because their NAEP identifiers were no longer available.

NAEP uses a complex balanced incomplete block (BIB) spiraled design. Accurate computation of average proficiency scores requires summation and then averaging five plausible values. Accurate computation of jackknifed standard errors requires the use of 56 replicate weights. Although these sophisticated statistical techniques are applied to produce accurate and appropriate means and standard errors, we present the analytical results in a more readily understandable format. Shown as percentages, means, and standard errors, results are presented in charts and tables.

Students who took the National Assessment of Educational Progress (NAEP) mathematics assessment in 1990 responded to questions about 11 specific high school math courses:

1. General math
2. Business or Consumer Math
3. Pre-Algebra
4. First-Year Algebra
5. Geometry
6. Analytic Geometry
7. Second-Year Algebra
8. Trigonometry
9. Pre-Calculus or Third-Year Algebra
10. Calculus
11. Probability or Statistics

The NAEP background questions asked students how long they took each of the 11 courses. Students had 4 response options:

1. More than 1 year
2. One year
3. Half-year or less
4. Not studied

In 1991, the High School Transcript Study (HSTS) used 51 math course codes from the Classification of Secondary School Courses (CSSC) taxonomy[1]. In the HSTS student file, courses are combined into 9 categories. Pre-Algebra is grouped with Algebra I and Analytic Geometry is grouped with Geometry. Business or Consumer Math is not

[1] Recently, NCES decided to use the Secondary Schools Taxonomy (SST) for all NCES publications in order to promote a uniform indicator. The taxonomy used in the 1990 HSTS differs from the SST in its treatment of 1) Pre-Algebra , 2) Analytic Geometry and 3) Algebra II, Trigonometry, Pre-Calculus, and Probability and Statistics. In the HSTS Pre-Algebra is grouped with Algebra I but in the SST they are separate. In the HSTS, Algebra II, Trigonometry, Pre-Calculus, and Probability and Statistics are in four distinct categories but in the SST they are combined into one category called 'advanced-other'. In HSTS Analytic Geometry is grouped with Geometry but in the SST it is included in the 'advanced-other' category.

listed in any of the groups. Dummy variables indicate whether the student took or did not take the specified minimum number of carnegie units. One half unit is the threshold for Algebra II, Trigonometry, Pre-Calculus and Statistics/Probability. One unit is the threshold for the other courses (Remedial or below-grade math, Algebra I, Geometry, and Calculus).

How well do students' reports match their transcripts?

The first step examines how closely students' reports of course taking match their transcripts. When matching students' reported course-taking to their transcript, the variables were constructed to be as similar as possible. Of necessity, the match measure uses the least common denominator approach for combined courses. Algebra I is combined with Pre-Algebra, and Analytic Geometry is combined with Geometry in the self-report data so that these will be as comparable as possible with the transcript data; Calculus is combined with Calculus AP in the transcript data so that it will be as comparable as possible with the self-report data[2].

Length of study is also taken into account. One half year or less in the self-report data was used for courses with a threshold of ½ carnegie unit in the transcript data and an analogous structure was employed for courses with a 1 year minimum .

There is some potential slippage here. Students who reported studying a math course for a half year or less may not have earned ½ carnegie units. It is conceivable that students who dropped a course may have responded that they took the course for less than one half year, but, since they did not receive any credit, their transcript record would record no credit for the course. Consumer or Business math was not used for matching in the NAEP variable. However, very few students took one year of Business or Consumer Math but did not take one year of General Math.

Given these cautions and caveats, how well do students' report of course-taking match their transcripts? Fewer than half of the students (42.3%) have an exact match. The remaining 57.7% (2253 students)[3] exhibit a discrepancy in 1 or more of the courses. Most of these students have a mismatch in only one course (32% of all HSTS students). Half again as many (16.3%) show variations in 2 courses, 6.2% have 3 course discrepancies and the remaining 3.4% diverge in 4 to 7 courses.

The type of mismatches is of more interest than is the number. Are students' exaggerating how much math they have taken? Not always. 438 (19%) of the discrepant group received transcript credit for courses that either they do not report taking (325 students) or that the students claimed to have studied for ½ year or less but the course has a threshold of 1 carnegie unit (113 students). Only six students received credit under

[2] Researchers should note that the students' transcript file is available for a more detailed examination.
[3] These numbers are not weighted.

both of these conditions. Most of the students, however, (1815) reported taking courses for which they did not receive the minimum credits required by the HSTS. 232 students stated that they took a one-unit-minimum-course for ½ year and 1583 – by far the largest group-- claimed credit for courses that were not on their transcript.[4] Some of the students who received transcript credit for courses they did not report taking, also claimed to take courses for which they did not receive credit. (263 students).

Nature and Patterns of Discrepancies

Discrepancies are not limited to just a few courses. Remembering that some students have 2 or more disjunctures, the disparity between transcripts and students' reports for each course are, in order of prevalence:

- Trigonometry 849,
- Pre-Algebra/Algebra I 731,
- Algebra II 595,
- Pre-Calculus 572,
- Probability or Statistics 441,
- Geometry 426,
- Calculus 201.

Among the 2253 students with at least one discrepancy between their reports and that of their transcripts, 274 patterns occur. The large number is due in part to the fact that there are four ways a student's report can differ from his transcript and there are seven courses which can be disparate.[5] Only 10 patterns describe more than 50 students and only 4 patterns describe more than 100 students. Reflecting both the disparity by course and the most common source of disjunctures, these 4 patterns involve students claiming they took a course but have no transcript credit for a single course:

- Trigonometry (268 students),
- Algebra II (211 students),
- Algebra I (195 students), and

[4] 236 students have a foot in both camps. They received credit for courses they claimed they either did not take or that they took for ½ year when the minimum threshold was 1 year and they did not receive credit for courses they claimed that they took under mirror conditions.

[5] The HSTS has one variable each for Calculus and Calculus AP so these are combined in order to make the match variables comparable between data sets.

- Pre-Calculus (105 students).

Students whose transcripts diverge from their own reports for more than one subject –and that occur for more than 50 students involve either Trigonometry or Pre-Calculus. The four patterns are:

- Trigonometry and Statistics (68 students),
- Trigonometry and Pre-Calculus (67 students),
- Algebra I and Pre-Calculus (62 students),
- Algebra I and Trigonometry (58 students),

Measuring Math Course-Taking

Is there any difference in average math proficiency scores when the source of math course-taking is transcript data as opposed to the students' report? In order to assess this relationship, average NAEP proficiency scores are computed for several measures of mathematics study. For these measures the indicators are developed independently for each data source. For example, the measure of the number of math courses taken is counted for 11 courses on the NAEP background questionnaire, but for 9 courses on the transcript. Furthermore, the self-report data allow one to count 4 courses if they were taken for ½ year, but the transcript data would not count unless they were taken for the minimum of one carnegie unit. Consequently, the maximum number of courses is 11 in the self-report data, but the maximum is 9 courses in the HSTS student file. This strategy is used to permit a comparison of outcomes that would occur with selected measures if only one data set were used– a common event in research.[6] In other words, we are asking "What if the data source were self-report instead of transcript? How would this affect the reporting of average proficiency?"

Most existing research that examines the relationship between mathematics study in high school and mathematics proficiency tries to capture the variety of mathematics course-taking in high school by using either the highest math course taken or the number of mathematics events. The counted 'events' are either all mathematics courses, academic math courses, semesters or years of mathematics study. We will look at three of these measures as well as extensions of the 'highest math course' measure. The three measures are number of mathematics courses, number of academic courses, and highest course taken. Number of semesters is not used because HSTS does not show this information on the student file. In addition to these measures currently in use, we introduce a new measure of mathematics study that attempts to tap the complexity of

[6] Note that this is different than the strategy used to assess how well the two sources mesh in their report of mathematics course taking. For that measure, we made the measure as comparable as possible for both data sources.

high school students' math course-taking behavior. Average NAEP proficiency scores are presented and compared for each indicator.

Measures of Math Course Taking

A. Current measures of course taking:

1. Number of
   a) Math courses
   b) Academic math courses
   c) Semesters or years (not used in this study.)
2. Highest course
   a) Highest Course + prerequisites (an extension of the Highest Course measure.)

B. New measure

Subset of math courses taken.

Each indicator is at least an ordinal level measure; indicators for number of events are interval.

For each measure we examine two types of results:

1. the pattern of the relationship between the indicator and average NAEP proficiency scores, and
2. provided the pattern is roughly similar for both transcript and self-report data, differences in average proficiency between similar categories from self-report and transcript data.

The underlying hypotheses are:

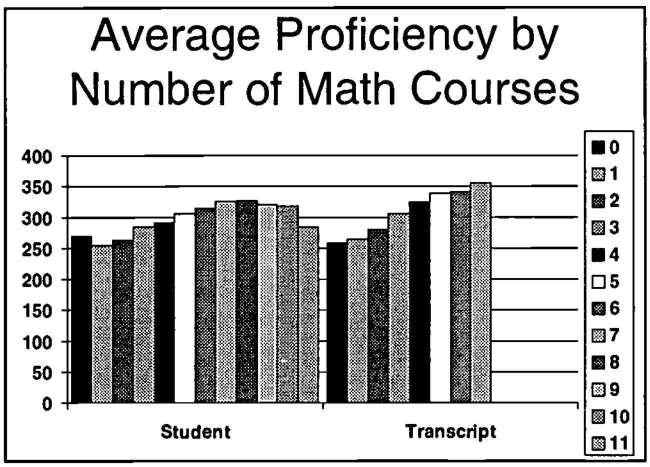
1. Average proficiency scores increase with each increment in math course-taking.
2. Since it is assumed that transcript data are more likely to be accurate than self-report data, average proficiency scores are expected to be higher for transcript data than for students' reports. The implicit assumption is that students whose reports of course-taking differ from their transcripts are more likely to overstate than understate their history of math course-taking.

A couple of notes are necessary. First, because proficiency estimates are not reliable when they are based on fewer than 62 students, average proficiencies will not be discussed or considered for categories which do not meet this threshold. In some cases, however, the categories are shown in graphs and tables in order to provide the full distribution. Second, there are usually two graphs for each indicator. Both graphs for a given indicator use the same data but present the data in a manner appropriate to the relevant text discussion.

First Indicator: Number of Math Courses

The first indicator is the number of mathematics courses taken in high school. When using student self-report data for number of courses, average proficiency is not monotonic. Average proficiency, which ranges from 255 to 321, increases from 1 to 7 courses, plateaus for 8 courses, then declines for 9 courses. In addition, there are few students at the extremes and standard errors are large. Proficiency estimates are statistically significantly different for each additional course between 1 and 7 but not between 7 and 9. Other categories (i.e. 0, 10, and 11) have fewer than 62 students. It seems quite unrealistic that any student would take all 11 of the math courses; it is difficult to envision anyone taking both calculus and general math during high school.

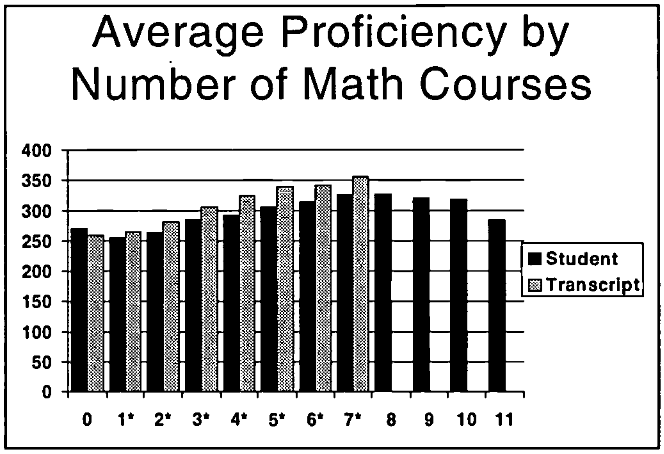
Looking at the number of courses indicator in the transcript file, proficiency scores are pleasingly monotonic. Average proficiency scores increase from 264 at 1 course to 339 at 5 courses. Each increment in this range is statistically significant. Like the self-report data, there are few students and large standard errors at the extremes.



NUMBER OF MATH COURSES

	STUDENT			TRANSCRIPT		
# Courses	# students	Mean prof.	st error	# students	Mean prof.	st error
Total	3903	297	1.20	3903	297	1.20
0	39	269	3.40	37	258	3.91
1	91	255	2.59	565	264	1.39
2	257	263	1.38	963	281	1.47
3	661	286	1.37	1295	305	1.15
4	922	292	1.56	760	324	1.65
5	806	306	1.93	247	339	3.25
6	504	314	1.65	35	342	5.45
7	303	325	2.50	1	356	7.42
8	178	327	3.14			
9	88	321	4.23			
10	36	318	5.22			
11	18	284	6.83			

Average proficiency scores tend to be much higher for any given number of courses in the transcript file vis a vis the self-report. Differences range from 9 to 33 points. Some of the differences may occur because a given number may mean different math course-taking experience for one data source vis a vis the other as well as between students within a single data set. For example, students who report taking only General Math and Business or Consumer Math in the self-report file would be counted as taking 2 courses, as would students in either data set who report taking only Algebra I and Geometry. Although all of these students have taken 2 courses, their study of mathematics is not comparable.

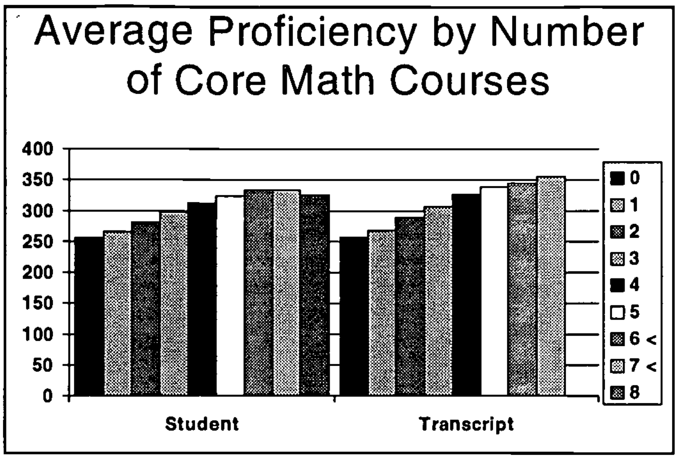


Second Indicator: Number of Academic Math Courses

The second indicator is the number of **academic** mathematics courses taken in high school. The use of academic or core math courses as a measure yields a more stable monotonic pattern between 0 and 6 courses for the self-reported data. Neither the plateau between 6 and 7 courses nor the decline between 7 and 8 courses, which is the terminal category in this distribution, is significant. Average proficiency scores range from 256 for 0 courses to 334 for 6 courses. Compared with the number of math courses indicator, this variable appears to reduce some of the noise.

The analogous transcript study indicator continues to exhibit a monotonic pattern. Average proficiency increases from 257 for 0 courses to 339 for 5 courses. Few students received credit for 6 or 7 courses.

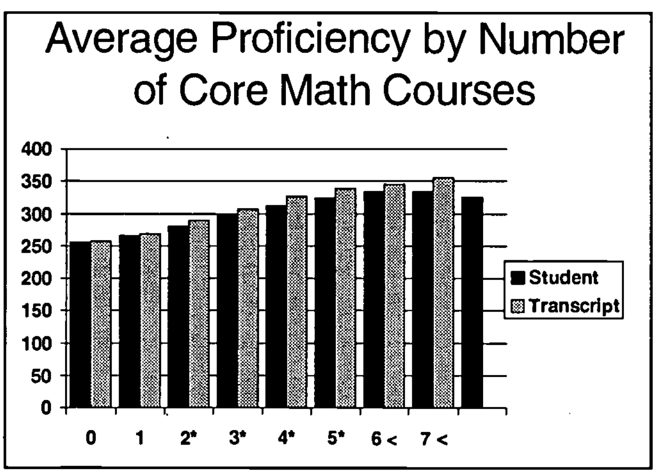
Less disparity exists between the self-reported and transcript data for this indicator than that which occurs when the number of all math courses is used. The range for this indicator differs by only 1 point at the lower end (viz. 256 vs. 257) and 4 points at the upper end (viz. 335 vs. 339). Differences were 9 and 18 points respectively for all math courses.



NUMBER OF ACADEMIC MATH COURSES

# Courses	STUDENT # students	Mean prof.	st error	TRANSCRIPT # students	Mean prof.	st error
Total	3903	297	1.20	3903	297	1.20
0	385	256	1.16	331	257	1.52
1	372	266	1.45	579	268	1.25
2	532	281	1.60	782	289	1.60
3	881	298	1.11	1224	307	1.09
4	620	312	1.40	712	326	1.51
5	578	325	1.27	245	339	3.26
6	316	334	2.19	29	345	5.63
7	155	335	2.56	1	356	7.42
8	64	326	4.20			

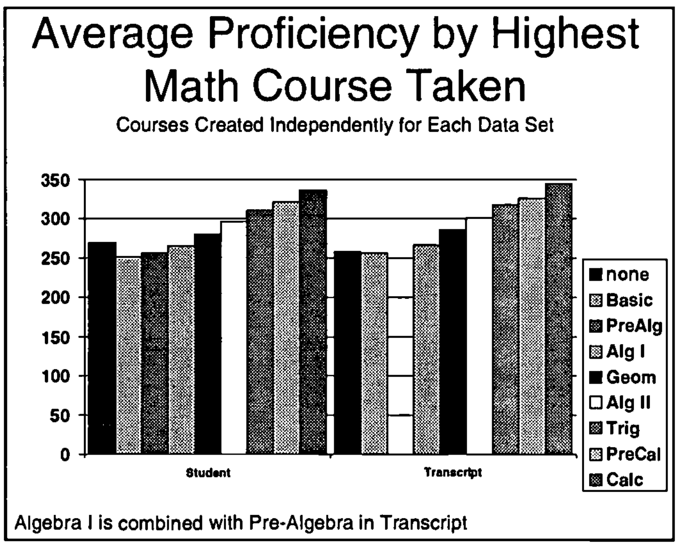
Nevertheless, notable differences in average proficiency still occur between the self-report and transcript indicator for 2 core courses through 5 core courses. Differences range from 8 to 14 points. Proficiency differences in the two data sets are not statistically different for either 0 or 1 course.



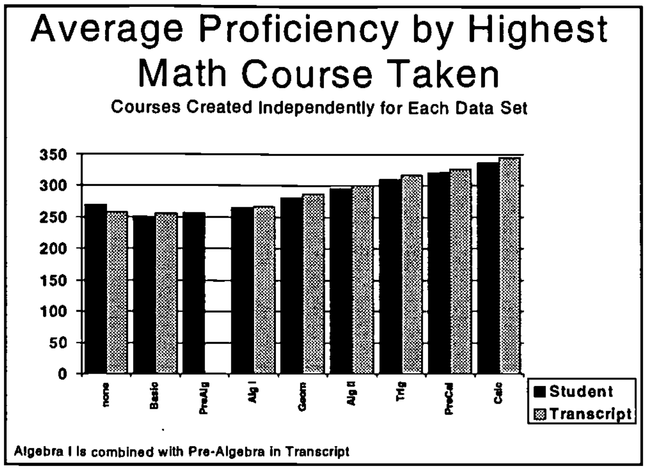
Third Indicator: Highest Math Course Taken

Another commonly used measure is the highest math course taken. This measure provides a qualitative component to the implicit quantitative aspect (i.e. higher courses imply that prerequisites were met so more courses were taken at higher course levels than at lower course levels).

Average proficiency increases monotonically between Algebra I and Calculus for both the self-report and transcript data. In addition, the increase in proficiency between Basic Math and Algebra I is significant in the transcript data but not in the self-report data. Note that this is the first time that the indicator for both data sets reveals the same relationship with average math proficiency and differences between each ordered academic category and its adjacent categories are significantly different.



Although the pattern is consistent for both data sets, average proficiency scores in the transcript data are larger than those in the self-report data for several courses. Ranging between 5 and 8 points, larger means occur for Algebra II, Trigonometry, and Calculus in the transcript data than in the self-report data. However, the means for Basic Math, Algebra I, Geometry and Pre-Calculus are not significant. In this instance, Algebra I from the self-report is compared with Algebra I/Pre-Algebra combination from the transcript. It is this inappropriate match which accounts for the nonsignificant difference. If Algebra I and Pre-Algebra are combined in both data sets, the mean from the transcript study is significantly larger than the mean from the self-report.



HIGHEST MATH COURSE TAKEN

Highest Course Taken	STUDENT Number of students	Mean prof.	st error	TRANSCRIPT Number of students	Mean prof.	st error
Total	3903	297	1.20	3903	297	1.20
none	39	269	3.40	37	258	3.91
Basic/General	171	251	1.89	297	256	1.58
Pre-Algebra	187	257	1.48			
Algebra I	334	265	1.39			
A1& Pre-Algebra	521	262	1.05	561	267	1.24
Geometry	462	281	1.69	560	287	1.98
Algebra II	960	296	1.11	1206	301	1.18
Trigonometry	602	311	1.64	443	318	2.03
Pre-Calculus	671	322	1.51	474	326	1.70
Calculus	464	337	1.99	325	345	1.88
Analytic Geometry	13	268	7.75			

The range of average proficiency scores for the highest course taken indicator is not as narrow as the range for number of academic math courses taken, and not as wide as the range for the number of all math courses taken. The range for this indicator differs by 5 points at the lower end (viz. 251 vs. 256) and 8 points at the upper end (viz. 337 vs. 345).

An Extension of the Highest Math Course Taken Indicator

We expanded the highest-math-course indicator to include prerequisite courses. Given the assumed sequence of:

Algebra I
Geometry
Algebra II
Trigonometry
Pre-Calculus
Calculus,

the immediately preceding courses were defined as prerequisite courses. Thus Algebra II is the first prerequisite for Trigonometry, and Geometry and Algebra II comprise two prerequisites for Trigonometry. Algebra I has no prerequisites and Geometry has Algebra I as its sole prerequisite. As the number of prerequisites increase, the number of courses which can be distinguished by adding immediate prerequisites decreases. For example, with 2 prerequisites only four courses can be distinguished – Algebra II, Trigonometry, Pre-Calculus and Calculus.

The results for both the self-report and the transcript data show minute changes in proficiency between the highest math course taken and highest math course taken plus varying numbers of prerequisites for students who had the necessary prerequisites.. Differences in proficiency between students who have taken from 1 to 3 prerequisites and the average proficiency when only highest course taken is used (i.e. without any prerequisites) range from 1 to 4 points in the self-report data and from 0 to 4 points in the transcript data. None of these differences is statistically significant.

Larger differences are found in average proficiency between students who *lacked* prerequisites and students who met the prerequisites. Students who lacked prerequisites scored lower on average than students who took the prerequisites. When significant differences occurred, students who met the prerequisites scored higher than students who did not. These significant differences occur for Algebra II, Trigonometry and Pre-Calculus, but do not occur in every comparison. There is no obvious pattern other than the more frequent occurrence of significant differences in the self-report data. No significant difference occurs for Calculus. Note that several categories had fewer than the requisite 62 students. This more frequent occurrence in the self-report data suggests that there may be some misreporting of math study by students. However, the presence of significant differences in the transcript data suggest that variability exists in the course-taking between Geometry and Calculus.

Fourth Indicator: Combination of Math Courses Taken

Another potential indicator is the combination of math courses taken by students. To provide a simple way of referring to this combination of math courses, we will call this indicator 'math combinations'. This is an attempt to improve the indicator of mathematics study by incorporating the highest mathematics course taken as well as courses that generally precede it. It is an extension of the highest-math-course-taken-plus-prerequisites indicator but it is more flexible than the latter. It retains the highest math course, but adds a variable number of prerequisites. It also has the advantage of weeding out some potential measurement error. For example, students who claim to have taken Trigonometry as their terminal course, and who also claim to have taken neither Algebra II nor Geometry are put in a separate category because this is improbable behavior.

This indicator was initially developed for a different but related piece of research. At that time potential variations were also examined. It was adapted for the present study by taking into account the inclusion of one variable (viz. Analytic Geometry) and the exclusion of another (viz. Unified, Integrated or Sequential Math).

Math combinations assumes that the sequence of courses for high school mathematics is: Pre-Algebra, Algebra I, Geometry, Algebra II, Trigonometry, Pre-Calculus and Calculus. Probability and Statistics, and General, Business or Consumer Math are outside of this sequence. Analytic Geometry, which was asked about in the 1990 NAEP but not in 1992, straddles Algebra II and Trigonometry but is linked with Geometry in the 1990 HSTS student file. As a result, Analytic Geometry also is combined with Geometry.

The indicator, math combinations, focuses primarily on this sequence of courses, which is studied in college preparatory curricula, and, secondarily on the other courses. Whether or not a student takes Basic or Remedial Math, or General Mathematics, Business or Consumer mathematics, and/or Pre-Algebra is not considered for courses beginning with Algebra I. Similarly, Algebra I and Geometry are not considered at some of the advanced mathematics course combinations (e.g. Algebra II and Trigonometry) because these latter courses require mastery of Algebra I and Geometry respectively. This allows for the inclusion of students who studied these courses before high school—a not uncommon event,-- or through some means other than standard courses. Since cell sizes are likely to become smaller for combinations that include more advanced mathematics courses this approach also has the advantage of capturing the appropriate students with comparable mathematics education into cells of adequate size, while, at the same time, separating out students whose reported mathematics study seems improbable.

The procedure for grouping courses was an iterative one. It was acknowledged from the outset, however, that there would be a wide variety of combinations. Using the set of core courses, 21 combinations of courses were identified as likely combinations. Next the sets of courses taken by students which were not in the initial 21 combinations of courses were delineated. This led to a total of 73 sets. Some of these sets had very few students -- even only 1 or 2 students. For technical reasons, 62 students are required to report results for any category.

Gradually, similar categories were combined. Many of these combined categories included Probability/Statistics along with Algebra, Geometry, Trigonometry and Calculus. For example, students who reported taking Algebra II and Pre-Calculus were combined with students who reported taking, Trigonometry and Pre-Calculus and students in these 2 groups who took Probability or Statistics were grouped with those who did not. In other cases, a prerequisite course was dropped. For example, the handful of students who reported taking Algebra II but not Algebra I were merged with the large number of students who reported taking both Algebra II and Algebra I.

Table 1 shows included courses, excluded courses, and assumed or ignored courses for the various combinations. Mathematics course combinations are ordered from least to greatest. The first category captures students who took no mathematics course in high school; the last category includes students who took Calculus along with 2 courses from among Algebra II, Trigonometry and Pre-Calculus. The principles underlying the order is, primarily, the highest math course taken, and, secondarily, by the course(s) preceding the highest math course taken. For example, students who report Trigonometry as their highest course taken are grouped in categories that come after Algebra II and before Pre-Calculus. For the two categories with Trigonometry as the highest course, the Trigonometry with Algebra II combination places above the Trigonometry with Geometry but no Algebra II combination because Algebra II is a more advanced course than Geometry.

Four categories either appeared to be highly improbable or could not be reasonably combined with any other categories and had too few students (viz. less than 62) to provide reliable estimates of proficiency scores. We decided to exclude these students from further analysis because, not only would their inclusion be more likely to obfuscate than illuminate the issue, but also their numbers sometimes were too small for reporting stable results. These four categories are:

- none (37 students)
- Geometry but no Algebra I (20 students)
- Calculus, or Pre-Calculus or Trigonometry only – no other course from Algebra II up (81 students)
- Calculus and either, Pre-Calculus, or Trigonometry or Algebra II (82 students).

The Geometry and Trigonometry category (< 45 students) and no math category (<40 students) also have too few students for reliable estimates. They were retained in the charts and tables because, in another study we did, these categories met the criteria of 62 students so it is useful to have this category to provide some level of closure. As a rule, however, these categories will not be discussed in analysis.

One additional note is in order with respect to the category Calculus + 2. This includes students who took Calculus as well as 2 out of the 3 preceding courses of Pre-Calculus, Trigonometry and Algebra II. In this study it also includes students who took Calculus as well as all 3 of the courses preceding it in the hierarchy. This was necessary because only 14 students received credit for all 4 courses on their transcript.[7] In comparison, 192 students reported taking all four courses and another 90 students reported taking these four courses as well as Probability and/or Statistics.

In comparing average proficiency scores from the transcript data with self-reported data, we find that – consistent with other indicators – average proficiency scores from Algebra I to Calculus + 2 tend to be a little higher for transcript data than for self-report data. The largest difference is 9 points which occurs for Algebra II/Trigonometry. A couple of these differences (viz. Algebra I /Geometry, Algebra II, and Algebra II / Trigonometry /Pre-Calculus) are not statistically significant

[7] Research on 1992 NAEP math proficiency by the author had a sufficient number of cases for each of these two categories.

Table 1: Mathematics Courses Taken By Students: 1990											
	High School Mathematics Courses										
Math Courses	General Math	Pre-Algebra	Algebra I	Geometry	Analytic Geometry	Algebra II	Trigonometry	Pre-calculus	Calculus	Probability or Statistics	Mnemonic used in tables and charts
1. None	-	-	-	-	-	-	-	-	-	-	None
2. General, Business or	+	-	-	-	-	-	-	-	-		gn-bs
Consumer Math											
3. Pre-Algebra		+	-	-	-	-	-	-	-		pa
4. Algebra I			+	-	-	-	-	-	-		a1
5. Algebra I & Geometry			+	a	a	-	-	-	-		a1/ge
6. Algebra II				-	-	+	-	-	-		a2
7. Geometry & Algebra II				a	a	+	-	-	-		ge/a2
8. Geometry & Trigonometry				a	a	-	+	-	-		ge/tr
9. Algebra II & Trigonometry						+	+	-	-		a2/tr
10.Algebra II & Pre-calculus OR						+	-	+	-		a2/pc OR tr/pc
Trigonometry & Pre-calculus						-	+	+	-		
11. Algebra II, Trigonometry						+	+	+	-		a2/tr/pc
& Pre-calculus											
12.* Calculus + 2 of (Algebra II,						+	+	-	+		cl +2
Trigonometry,						+	-	+	+		
and Pre-calculus)						-	+	+	+		
13.* Algebra II, Trigonometry,						+	+	+	+	-	a2/tr/pc/cl
Pre-Calculus & Calculus											
14.* Algebra II, Trigonometry,						+	+	+	+	+	a2/tr/pc/cl/S
Pre-Calculus & Calculus &											
(Statistics)											
* Categories were combined into the CL + 2 category because some cells have fewer than 62 students.											
15. Geometry			-	a	a	-	-	-	-		Mathematics proficiency of
16. Calculus OR						-	-	-	+		students reporting these
Pre-calculus OR						-	-	+	-		course combinations are
Trigonometry				-	-	-	+	-	-		not presented in this paper
17. Calculus + 1 of											because the combination
(Pre-calculus, OR						-	-	+	+		of courses seem improbable
Trigonometry OR						-	+	-	+		and/or there were fewer
Algebra II)						+	-	-	+		than 62 students in the
											category.
+ = Students took math course.											
- = Students did not take math course.											
a= Students took at least one of the courses marked.											
blank = Course not considered. Some students may have taken this course;											
other students may not have taken this course.											

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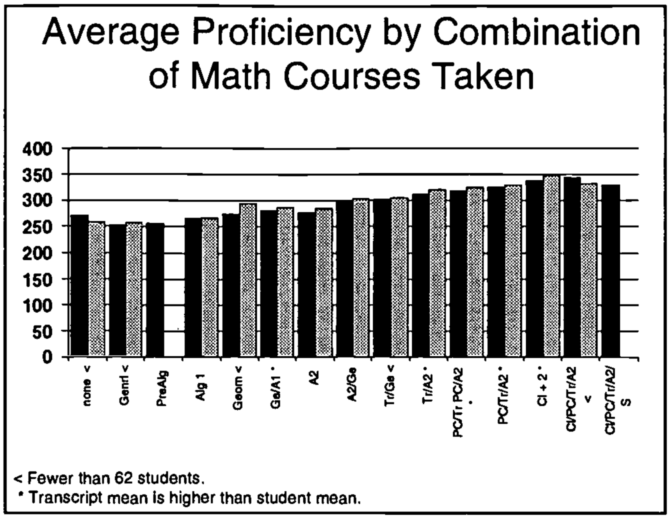


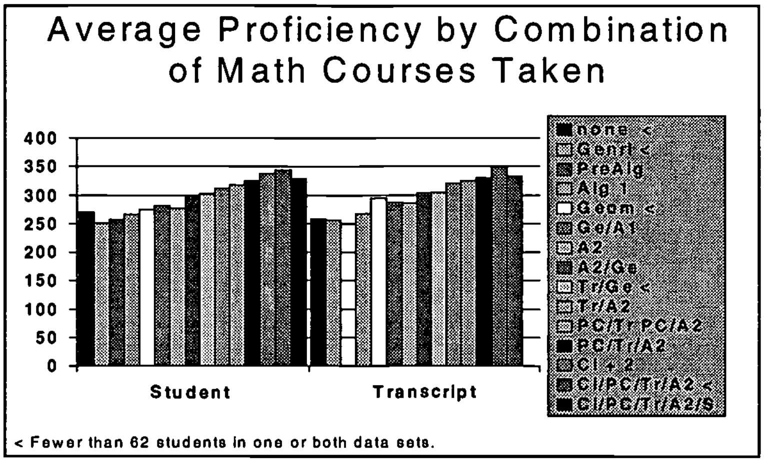
COMBINATION OF MATH COURSES TAKEN

	STUDENT			TRANSCRIPT		
	Number students	Mean prof.	standard error	Number students	Mean prof.	standard error
Total	3903	297	1.20	3903	297	1.20
none	39	269	3.40	37	258	3.91
gn-bs-cnsm	171	251	1.89	297	256	1.58
pre-alg	187	257	1.48			
a1	334	265	1.39	561	267	1.24
//A1&prealg	521	262	1.05			
ge	47	274	4.70	20	294	7.49
ge/a1	427	281	1.76	540	287	1.97
a2	91	277	3.21	128	286	2.25
a2/ge	869	299	1.09	1078	303	1.25
tr/ge	44	302	3.47	39	305	2.97
tr/a2	558	312	1.69	394	320	1.92
pc/tr or pc/a2	165	318	1.75	336	326	1.77
pc/tr/a2	493	326	1.45	100	330	4.59
cl+2	158	338	2.59	196	349	2.38
cl/pc/tr/a2	192	344	2.34	14	333	6.65
cl/pc/tr/a2/stat	90	329	3.30			
All CL	440	339	1.91	210	348	2.42

Turning our attention to the patterns across these two data sets, Average proficiency scores do not appear to be monotonic for either the self-report or transcript data. Instead it looks more like a saw-tooth pattern. (Recall that this is not consistent with highest-math-course-taken which revealed a monotonic pattern among academic math courses.) In the transcript data, average proficiency either plateaus or declines between:

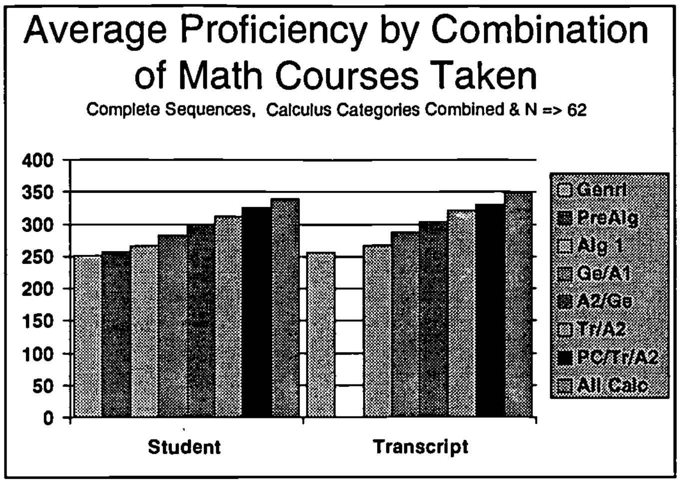
- Algebra I/Geometry and Algebra II,
- Geometry/Algebra II and Geometry/Trigonometry, and
- Algebra II/Pre-Calculus or Trigonometry/Pre-Calculus and Algebra II

/Trigonometry/Pre-Calculus.
In the self-report data, this plateau or decline pattern is evident only between Algebra I/Geometry and Algebra II.



Each of these groups has one category that has an incomplete sequence. These incomplete sequences are Algebra II which lacks Geometry, Geometry/Trigonometry which lacks Algebra II, and Algebra II/Pre-Calculus or Trigonometry/Pre-Calculus which lacks Trigonometry or Algebra II respectively. For two of the three patterns, the presumably higher category has the incomplete sequence. The fact that they all cluster around the middle categories in the sequence may reflect the wide variations in the labeling and content of Algebra II, Trigonometry and PreCalculus courses that occur among schools.

If the course combinations with incomplete sequences are removed, a monotonic pattern in average proficiency becomes apparent and differences in proficiency between each level from Algebra I upwards is statistically significant. Students in these three excluded categories represent 13% of the students in the transcript file; they represent 8 percent in the self-report file. Alternatively, students in the included categories represent 87% of the students in the transcript file; they represent 92 percent in the self-report file.



Summary

What do these data tell us? Let's make a list.

1. Exact match rates are low – less than 50% -- but the most of the non-matches involve only 1 course. Among mismatches, students usually claim to have a deeper math background than do their transcripts. However, a notable number of students report a more shallow background vis a vis their transcripts.
2. For most measures of mathematics study, there tends to be an increase in proficiency with each additional level of math study. The monotonic pattern shows a positive relation between average proficiency and the math study indicator. In one measure, -- number of math courses-- this monotonic pattern occurs only up to a point; in another measure – math combinations – it is not apparent until categories with incomplete sequences are removed.
3. This pattern occurs in both the self-report and the transcript data sets.
4. Although math combinations has only a marginally larger range than does highest-math-course-taken, (viz. 3 points in each data set), it provides additional qualitative information that distinguishes students by their math course-taking history and separates students who take complete sequences from those who do not. Students with incomplete sequences tend to have lower average scores than students with complete sequences.
5. For any given category in a measure, statistically significant differences in average proficiency scores show higher scores in the transcript data than in the self-report data. This suggests that using self-report data may result in marginally attenuated proficiency scores.

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